CLAIMS

What is claimed is:

1. A method for adjusting fractional amounts of primary colors to be combined to substantially match a user selected color and substrate characteristics in a device adapted to color printing on a substrate, the method comprising the steps of:

determining a compensated target transmission spectrum, $T_{comp}(\lambda)$ of a printable ink layer;

optimizing an uncompensated target transmission spectrum, $T_{un\text{-}comp}(\lambda)$ of a printable ink layer; and

comparing $T_{un\text{-}comp}(\lambda)$ with $T_{comp}(\lambda)$ plus a predetermined delta and selecting fractional amounts of primary colors to be combined to substantially match the user selected color and the substrate characteristics.

2. A method as in claim 1 wherein the step of determining the compensated target transmission spectrum, $T_{comp}(\lambda)$, further comprises the steps of:

determining a color reflection spectrum, $R_{tgt}(\lambda)$;

determining a substrate reflection spectrum, $R_s(\lambda)$;

determining an average front surface substrate reflection, R_{fs}; and

combining $R_{tgt}(\lambda)$, $R_s(\lambda)$, and R_{fs} to produce the target transmission spectrum, T_{comp} (λ).

3. A method as in claim 2 wherein the step of combining $R_{tgt}(\lambda)$, $R_s(\lambda)$, and R_{fs} to produce a target transmission spectrum, T_{comp} (λ) further comprises the steps of:

determining T_{comp} (λ), according to the equation:

$$T_{comp}(\lambda) = SQRT\ ((R_{tgt}(\lambda) - R_{fs})/((1-R_{fs})*R_s(\lambda))),$$

where SQRT = square root of.

4. A method as in claim 1 wherein the step of optimizing the uncompensated target transmission spectrum, $T_{un\text{-}comp}$ (λ) further comprises the step of optimizing:

$$T_{un\text{-}comp}(\lambda) = F(PMA_j,\ \alpha_j(\lambda),\ j=1,n)$$

where

PMA_j = the printed mass per unit area associated with the primary colorant j; and

α_j = the absorption coefficient of the j-th colorant at wavelength λ.

5. A method as in claim 4 wherein the step of optimizing $T_{un\text{-}comp}(\lambda)$ further comprises the steps of:

measuring reflection spectra of known PMA_j for j=1,n, where n is the number of primary colorants;

determining $\alpha_j(\lambda)$ and empirical adjustments to the approximate equation, $T_{un\text{-}comp}(\lambda) = \exp(-\Sigma_j\ PMA_j*\alpha_j(\lambda)\ )$,

where exp = 2.71828..., such that the accuracy of the empirical equation, $R(\lambda) = R_{fs} + (1-R_{fs})*T(\lambda)*R_s(\lambda)*T(\lambda)$, is improved; and

selecting at least one combination of PMA_j such that the calculated $T_{un-comp}(\lambda)$ plus or minus the predetermined delta substantially equals $T_{comp}(\lambda)$.

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6. A method as in claim 5 wherein the step of selecting at least one combination of ~~α_j~~ PMA_j and ~~$MC_j(\lambda)$~~ $\alpha_j(\lambda)$ further comprises the steps of:

determining a printed mass per unit area (PMA) per primary color, PMA_j;

determining the total PMA_{tot} according to $\sum_j PMA_j$, for j= 1 to n, where n= number of primary colors;

calculating the fractional amount of primary color, Fj, according to $Fj = PMA_j/PMA_{tot}$; and

determining if the fractional amount F_j is below a predetermined reservoir level for that j-th color and selecting an alternate combination of PMA_j such that the calculated $T_{un-comp}(\lambda)$ plus or minus the predetermined delta substantially equals $T_{comp}(\lambda)$..

7. A method as in claim 1 wherein the step of comparing $T_{un-comp}$ (λ) with T_{comp} (λ) plus a predetermined delta and selecting fractional amounts of primary colors to be combined further comprises the step of selecting fractional amounts of primary colors from a composition table.

8. A method as in claim 2 wherein the step of determining the color reflection spectrum coefficient, $R_{tgt}(\lambda)$ further comprises the step of selecting R_{tgt} from a database.

9. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, $R_s(\lambda)$ further comprises the step of selecting $R_s(\lambda)$ from a database.

10. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, $R_s(\lambda)$ further comprises the step of selecting $R_s(\lambda)$ from a database.

11. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, $R_s(\lambda)$ further comprises the step of measuring $R_s(\lambda)$.

12. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, $R_s(\lambda)$ further comprises the step of reading $R_s(\lambda)$ from a packaging label.

13. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, R_{fs} further comprises the step of selecting R_{fs} from a database.

14. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, R_{fs} further comprises the step of measuring R_{fs}.

15. A method as in claim 2 wherein the step of determining the substrate reflection spectrum coefficient, R_{fs} further comprises the step of reading R_{fs} from a packaging label.

16. A method for determining optical characteristics of a substrate to be printed on and adjusting color components of a desired color to compensate for said optical characteristics, the method comprising the steps of:

determining optical characteristics of a desired color;

determining optical characteristics of the substrate to be printed on; and

comparing the optical characteristics of the desired color and the optical characteristics of the substrate to be printed on and adjusting the color components of the desired color to compensate for said optical characteristics of the substrate to be printed on.

17. A method as in claim 16 wherein the step of determining the optical characteristics for the desired color further comprises the step of determining the reflection spectrum of the desired color.

18. A method as in claim 16 wherein the step of determining optical characteristics of the substrate to be printed on further comprises the steps of:

determining the reflection spectrum of the substrate to be printed on; and

determining the average front surface reflection of the substrate to be printed on.

19. A color mixing system in an apparatus adapted to printing color documents, the system comprising:

a source of a plurality of primary colorants;

at least one optical characteristic source;

at least one user interface; and

a controller connectable to the at least one optical characteristic source and the at least one user interface, wherein the controller controls mixing of a plurality of primary colors from the source of primary colorants in response to the at least one optical characteristic source and the at least one user interface.

20. A color mixing system as in claim 19 wherein the at least one optical characteristic source further comprises a substrate reflection spectrum $R_s(\lambda)$ sensing device, alternatively the at least one optical characteristic source comprises a stored table of $R_s(\lambda)$ values.

21. A color mixing system as in claim 19 wherein the at least one optical characteristic source is a substrate average front surface reflection R_{fs} sensing device, or a stored table of R_{fs} values.

22. A color mixing system as in claim 19 wherein the at least one optical characteristic source further comprises a reflection spectrum database having at least one reflection spectrum $R_{tgt}(\lambda)$ of a user selected color.

23. A program storage device readable by a machine, tangibly embodying a program of instructions executable by the machine to perform method steps for adjusting fractional amounts of primary colors to be combined to substantially match a user selected color and substrate characteristics in a device adapted to color printing on a substrate, the method comprising the steps of:

determining a compensated target transmission spectrum, $T_{comp}(\lambda)$ of a printable ink layer, further comprises the steps of determining a color reflection spectrum, $R_{tgt}(\lambda)$, determining a substrate reflection spectrum, $R_s(\lambda)$, determining an average front surface substrate reflection, R_{fs}, combining $R_{tgt}(\lambda)$, $R_s(\lambda)$, and R_{fs} to produce the target transmission spectrum, $T_{comp}(\lambda)$;

optimizing an uncompensated target transmission spectrum, $T_{un\text{-}comp}(\lambda)$ of a printable ink layer, further comprises the step of optimizing:

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$\cancel{T_{un\text{-}comp}(\lambda) = \exp(\Sigma_j \alpha_j MC_j(\lambda))}$, where exp= 2.71828 . . .

$T_{un\text{-}comp}(\lambda) = \exp(-\sum_j PMA_j \cdot \alpha_j(\lambda))$

~~α_j = a mathematical mass associated with each primary~~

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~~color j,~~ PMA_j = the printed mass per unit area associated with the primary color j,

$MC_j(\lambda))$, = the master curve ~~associated with each~~

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~~primary color j, and~~ $\alpha_j(\lambda)$ = the color absorption spectrum associated with primary color j, and

optimizing an uncompensated target transmission spectrum, $T_{un\text{-}comp}(\lambda)$ of a printable ink layer, further comprises the steps of:

adjusting PMA_j to minimize differences between $T_{un\text{-}comp}(\lambda) = F[\ PMA_j,\ \alpha_j(\lambda),\ j = 1,N\ ]$ and $T_{comp}(\lambda)$, where PMA_j is the printed mass per unit area of the j-th primary color, $\alpha_j(\lambda)$ is the absorption coefficient of the j-th primary color at wavelength λ; and

comparing $T_{un\text{-}comp}(\lambda)$ with $T_{comp}(\lambda)$ plus or minus a predetermined delta and selecting fractional amounts of primary colors to be combined to substantially match the user selected color and the substrate characteristics.